UNITED
NATIONS

A

General Assembly

Distr.
GENERAL

A/AC.105/510/Add.1
21 February 1992
ENGLISH
ORIGINAL: CHINESE/ENGLISH

COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

NATIONAL RESEARCH ON THE QUESTION OF SPACE DEBRIS

Note by the Secretariat

Addendum

The present document contains information provided in replies received from Member States up to 20 February 1992.

CONTENTS

	Page
BULGARIA	2
CHINA	3
DENMARK	14

92-07924 3148e 280292 280292

020392

/...

BULGARIA

[Original: English]

INVESTIGATION OF AIR AND SPACE SYSTEM SAFETY BASED ON ANALYTICAL CRITERIA

(Research paper by B. I. Madjarov, Space Research Institute)

The high reliability of aerospace systems ensures a very low risk of accidents arising from emergency situations (1:1,000,000 to 1:10,000,000) and a practically negligible risk of fatal accidents (1:10,000,000 to 1:1,000,000,000). The general approach to system standardization, both theoretical and practical, based on various methods of statistical investigation of phenomena, is unsatisfactory for the analysis of such situations and does not allow for realistic prediction of dangerous but low-probability phenomena.

We therefore suggest an approach and methods for the analytical evaluation of risks in high-reliability systems, such as space and aviation systems, nuclear power stations, etc. A principal consideration in relating the probability of specific situations to the risk of their leading to a serious accident is the investigation of the final terms of a statistical sampling procedure based on values characterizing the state of the systems in the form of a multi-modal distribution. This investigation is based on proof that the final terms are not determined by the distribution laws for the values that define the state.

Analytical criteria are suggested for estimating the risk level and determining its dependence on four groups of adverse factors: operator errors (in the operator-machine system and in polyergatic systems); technical systems failure (for different schemes of redundancy distribution); the effect of external adverse factors; and errors in the organization, planning, management and control of system performance.

Two basically different types of research are identified:

- Analysis of the functional failure of a system with identification of the type of failure; estimation of the probability of occurrence; verification of the range of all failure states and combinations of states without estimation of the consequences of their occurrence;

- Identification of specific situations arising from functional failures; determination of the conditional probabilities for preventing the failures under different stages and conditions; development of steps for lowering the risk level.

On the basis of this research, automated systems for real-time monitoring and control of safety levels may be developed, together with a combination of approaches for the statistical and analytical determination of risk criteria for different adverse factors.

CHINA

[Original: Chinese]

THE STATUS OF SPACE DEBRIS STUDIES IN CHINA

Submitted by the Space Debris Study Group

(March 1991)

INTRODUCTION

With the expansion of human activities in space and the steady increase in space debris (or space trash) resulting therefrom, the space environment is constantly deteriorating. If left uncontrolled, this situation will gravely endanger future space activities, presenting ever greater hazards, particularly to manned space flights of extended duration.

The problem of the pollution of the space environment caused by space debris has become a growing concern within international astronautical circles and the international community as a whole. The General Assembly, in its resolution 44/46, adopted in 1989, requested that States attach great importance to the problem of space debris and carry out research at the national level. In its resolution entitled "International cooperation in the peaceful uses of outer space", adopted on 11 December 1990, at its forty-fifth session, the General Assembly once again pointed out that, "considering that space debris is an issue of concern to all nations, ... it is essential that Member States pay more attention to the problem of collisions with space debris and other aspects of space debris, and calls for the continuation of national research on this question". In a letter addressed to Governments on 30 June 1989, the Secretary-General of the United Nations stated that the management of the space environment was a matter for international cooperation and urged States to conduct national research and submit studies thereon.

Outer space is an invaluable natural resource which is shared by all mankind. It is a common desire among States to control and reduce space debris and protect the outer space environment. This is a matter of profound concern to the Chinese Government.

In June 1989 the Ministry of Aviation and Astronautics began organizing a Space Debris Study Group in order to give impetus to research on the problem of space debris. On 28 December 1989, the Ministry of Aviation and Astronautics organized a seminar on space debris in Beijing for the first time. Specialists from the State Science and Technology Commission, the Commission of Science and Technology for National Defense, the Ministry of Foreign Affairs, the Chinese Academy of Science and the Ministry of Aviation and Astronautics took part in the seminar and exchanged information on their research on space debris. Three other seminars were organized in Beijing in August and December 1990 and March 1991, which dealt in depth with the current

situation and trends in the development of debris in outer space, space debris produced by Chinese space activities and the technological means of reducing the generation of space debris, and made recommendations concerning positions and policies to be adopted on the problem of space debris.

I. CHINESE SPACE OBJECTS IN ORBIT AND POSSIBLE SPACE DEBRIS RESULTING FROM THEM

From 1970 to 1990, China successfully carried out 28 space launchings, placing 32 artificial satellites of various types into low-earth, sun-synchronous and geostationary orbits (including the Asia-1 communications satellite and the first experimental satellite for Pakistan, both launched in 1990).

By the end of 1990, a total of 30 artificial satellites designed and produced by China had been launched into outer space (see table 1), of which 10 remain in orbit. Five of them are in geostationary orbits, and the remaining five in other orbits. A total of 20 satellites have either been recovered (12) or fallen to earth (8). For example, the Shijian-1 scientific experimental satellite (International Code No. 1971-18A), which was launched on 3 March 1971, remained in normal space operation for eight years until it fell on 11 June 1979. In another case, the Shijian-2 scientific experimental satellite (universal designation PRC-09) was launched into orbit on 20 September 1981, but based on telemetric data received at 0300 hours on 3 October 1981, an increase was detected in the satellite's rotational speed, from 15-20 rpm to nearly 162 rpm; at 1400 hours on the same day it disappeared and no further signals were received. From this it was concluded that the satellite had disintegrated as a result of its high speed of rotation. At that time, 10 pieces of debris were entered in the NASA Tracking Register, all of which have since fallen to earth.

By the end of 1990, China had launched into orbit the final stages of 28 launch rockets (see table 2), of which 19 have fallen to earth and 9 remain in low-earth or geosynchronous transfer orbits.

Statistics show that, by the end of June 1990, a total of 4,048 spacecraft had been launched in the world, with China accounting for about 0.7 per cent of all launchings. Based on information provided by the United Nations Committee on the Peaceful Uses of Outer Space, the space debris produced by States that are less active in space, including China, accounts for less than 0.3 per cent of all tracked objects world wide, and its effect on the outer space environment as a whole is minimal - insignificant when compared to that produced by major Powers active in space, such as the United States of America and the Soviet Union.

II. POSITIONS OF PRINCIPLE ON SPACE DEBRIS

1. Outer space is an area for joint exploitation by mankind as a whole, and the preservation of the space environment is a common obligation of all States.

2. States which are major producers of space debris have the major responsibility for preserving the space environment and controlling space debris.

3. Space debris is a global problem, and only through international cooperation can space debris be successfully controlled. In order to reduce and control the generation of space debris, international cooperation in and exchanges of space technology should be encouraged and promoted, and States with experience in space-debris control technology should provide free technical assistance to other interested States.

4. China, being a developing country, has conducted only a limited number of space launchings, which have produced an insignificant amount of space debris. However, to facilitate man's free exploration and exploitation of outer space, China will strengthen its cooperation with other countries and international organizations, including the United States of America, the Soviet Union, the European Space Agency (ESA) and Japan, in order to promote actively the exchange of information and technology, search together for effective ways to reduce the generation of space debris and make genuine efforts to preserve the space environment.

5. Research on technology for reducing space debris should be encouraged and strengthened and technical measures should be taken to deal with satellites and the final stages of rockets sent into medium and high orbits which are liable to explode, thereby controlling and reducing the generation of space debris in so far as possible.

6. A "space environment protection fund" should be established under the Committee on the Peaceful Uses of Outer Space. Such a fund would be used mainly to:

(a) Support international research and technological exchange on controlling the generation of space debris, especially research conducted by developing countries;

(b) Establish a registration, management and information exchange system for space objects of all States; and

(c) Support international legislation on the problem of space debris.

III. STUDIES ON TECHNOLOGICAL MEANS FOR THE REDUCTION OF SPACE DEBRIS

1. Measures taken by China to reduce space debris

Bearing in mind the need to minimize the number of abandoned objects left in space orbit and to prevent them from disintegrating in space, China has taken a number of measures with regard to certain rockets and spacecraft in the development of its space technology. For example:

(a) When the cap for the infra-red probe on the Fengyun-1 meteorological satellite was jettisoned, it remained tethered to the satellite;

(b) Launch rocket design departments have imposed stringent technical requirements with regard to enclosure in the design of satellite-rocket separation devices to ensure that separated items do not scatter outside the main structure;

(c) Technical improvements have been made in certain orbital designs for the launching of geostationary satellites, lowering the geosynchronous transfer orbit's perigee from 400 km to 200 km; this greatly shortens the orbital lifetime of rocket final stages, thereby contributing to the reduction of space debris.

2. Further studies on technological means

(a) To the extent that overall performance requirements permit, spacecraft design is improved by making use of tethering to reduce the number of objects separated from the spacecraft during the process of launching into orbit;

(b) When conditions permit, the following technological measures are taken to shorten the orbital lifetime of the launch rocket's final stage after satellite-rocket separation:

- In choosing from alternative orbital designs, preference is given to those with lower perigees;

- "De-orbiting technology" is employed. After a medium or high-orbit satellite has been launched into orbit, the altitude of the final-stage rocket is adjusted to send it into a lower orbit, causing it eventually to burn up in the dense atmosphere;

(c) For those final stages of launch rockets using self-combustible propellants, methods are devised to release promptly all residual propellants and high-pressure gases remaining in the final-stage rockets to prevent any explosion while they remain in orbit.

IV. LEGAL QUESTIONS RELATING TO SPACE DEBRIS

1. China acceded to the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty) in December 1983 and to the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Agreement on Assistance), the Convention on Registration of Objects Launched into Outer Space (Registration Convention) and the Convention on International Liability for Damage Caused by Space Objects (Liability Convention) in December 1988.

China signed both conventions relating to radioactive space debris, i.e. the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, on 26 September 1986 and deposited the instruments of ratification on 14 September 1987.

Furthermore, the Chinese Government attaches great importance to the draft principles relevant to the use of nuclear power sources in outer space that are being elaborated by COPUOS and its Legal Subcommittee, in particular those relating to the question of pollution caused by radioactive space debris. It has been active in promoting progress in this work.

The Chinese Government strictly fulfils its international obligations under the international treaties it has signed.

2. Whether the Liability Convention applies to damage done to a State's space object by space debris is currently a subject of international debate. One view holds that a State whose space debris causes damage to a space object of another State should be liable to pay compensation in accordance with the provisions of the Liability Convention, on the grounds that the Registration Convention states that a "space object" includes component parts of a space object as well as its launch vehicle and parts thereof. In reality, this is a very complex problem. Firstly, the Liability Convention stipulates that such liability should be based on fault; secondly, it is sometimes impossible to identify space debris and to determine to whom it belongs, so that neither the cause of the damage nor the party liable for it can be determined under the Liability Convention. However there is no legal basis for an arbitrarily extended interpretation of the Liability Convention.

3. As to whether the launching State's consent is required before space debris belonging to that State (including satellites no longer in use) is destroyed or removed, the Outer Space Treaty provides that the launching State on whose registry a space object is carried shall retain jurisdiction and control over such object. It also stipulates that States should conduct their activities in outer space with due regard to the corresponding interests of other parties. This provision is the basis for the view that, once space debris and abandoned space objects exert an adverse effect on the space activities of other States, the affected State may legitimately take appropriate measures (such as destruction or removal) to prevent damage. This

view is also subject to debate. In general, any State wishing to destroy, remove or take any other measures against another State's space debris, especially a satellite that is no longer in use, should seek the consent of the space object's registering State, without which it should not take action. Of course, whether debris resulting from confirmed disintegration or broken residual fragments should be excluded from this provision is open to discussion.

In view of the inadequacy of the provisions concerning space debris in existing treaties, agreements or customary law, new international agreements must be adopted on the basis of in-depth studies and thorough consultations in order to settle certain questions relating to space debris.

TABLE I

LIST OF CHINESE SATELLITES LAUNCHED INTO OUTER SPACE

Sequence No.	Date launched	International Code No.	Satellite name	Satellite mass (kg)	Initial orbit				Remarks
					Altitude of perigee (km)	Altitude of apogee (km)	Orbital inclination (deg)	Orbital period (min)	
1	24/4/70	1970-34A	Dongfanghong-1 satellite	173	439	2 384	68.5	114	
2	3/3/71	1971-18A	Shijian-1 satellite	221	266	1 826	69.9	106	Fallen to earth (11/6/79)
3	26/7/75	1975-70A	Technical experimental satellite	1 109	186	464	69	91	Fallen to earth
4	26/11/75	1975-111A	Re-entry-type remote sensing satellite	1 790	173	483	63	91	Re-entry module retrieved, remainder fallen to earth
5	16/12/75	1975-119A	Technical experimental satellite	1 108	184	187	69	90	Fallen to earth
6	10/8/76	1976-87A	Technical experimental satellite	1 082	191	2 145	69	108.8	Fallen to earth
7	7/12/76	1976-117A	Re-entry-type remote sensing satellite	1 812	167	489	59	91	Re-entry module retrieved, remainder fallen to earth
8	26/1/78	1978-11A	Re-entry-type remote sensing satellite	1 810	163	488	57	91	Re-entry module retrieved, remainder fallen to earth
9	20/9/81	1981-93B	Shijian-2 satellite	257	237	1 622	60	103	Fell to earth after disintegration
10	20/9/81	1981-93C	Shijian-2A satellite	483	237	1 622	60	103	Fallen to earth
11	20/9/81	1981-93A	Shijian-2B satellite	15	237	1 622	60	103	Fallen to earth
12	9/9/82	1982-90A	Re-entry-type remote sensing satellite	1 783	169	195	63	90	Re-entry module retrieved, remainder fallen to earth
13	19/8/83	1983-86A	Re-entry-type remote sensing satellite	1 842	175	404	63	90	Re-entry module retrieved, remainder fallen to earth
14	29/1/84	1984-8A	Experimental satellite	433	360	6 480	36	161	
15	8/4/84	1984-35A	Experimental communications satellite	433	35 598.9	35 792.8	0.62	1 431.5	Fixed at 125° E; has drifted away
16	12/9/84	1984-98A	Re-entry-type remote sensing satellite	1 809	174	408	68	90	Re-entry module retrieved, remainder fallen to earth
17	21/10/85	1985-96A	Re-entry-type remote sensing satellite	1 820	173	402	63	90	Re-entry module retrieved, remainder fallen to earth
18	1/2/86	1986-10A	Operational communications and broadcasting satellite	433	35 783	35 792	0.09	1 436	Fixed at 103° E, has drifted away

TABLE 1 (continued)

Sequence No.	Date launched	International Code No.	Satellite name	Satellite mass (kg)	Initial orbit: Altitude of periqee (km)	Initial orbit: Altitude of apogee (km)	Initial orbit: Orbital inclination (deg)	Initial orbit: Orbital period (min)	Remarks
19	6/10/86	1986-76A	Re-entry-type remote sensing satellite	1 820	175	397	57	90	Re-entry module retrieved, remainder fallen to earth
20	5/8/87	1987-67A	Re-entry-type remote sensing satellite	1 820	175	489	63	90	Re-entry module retrieved, remainder fallen to earth
21	9/9/87	1987-75A	Re-entry-type remote sensing satellite	2 100	205	315	63	89	Re-entry module retrieved, remainder fallen to earth
22	7/3/88	1988-14A	Operational communications satellite	441	35 786.4	35 862.6	0.07	1 438	Fixed at 87.5° E
23	5/8/88	1988-67A	Re-entry-type remote sensing satellite	2 100	175	400	63	90	Re-entry module retrieved, remainder fallen to earth
24	7/9/88	1988-80A	Fengyun-1 satellite	780	883	918	99.1	102.8	
25	22/12/88	1988-111A	Operational communications satellite	441	35 782.5	35 790.2	0.56	1 .1	Fixed at 110.5° E
26	4/2/90	1990-11A	Operational communications satellite	441	35 783.3	35 797.8	0.11	1 436.3	Fixed at 98° E
27	3/9/90	1990-81A	Fengyun-1 satellite	841	.6	905.7	99.9	102.9	
28	3/9/90	1990-81B	Daqi-1A satellite	3	900.6	905.7	99.9	102.8	Fell to earth on 12/3/91
29	3/9/90	1990-81C	Daqi-1B satellite	4	900.6	905.7	99.9	102.8	
30	5/10/90	1990-89A	Re-entry-type remote sensing satellite	2 100	210	328	63	89	Re-entry module retrieved, remainder fallen to earth

TABLE 2

LIST OF LAUNCH ROCKET FINAL STAGES PUT INTO ORBIT AT VARIOUS TIMES DURING CHINA'S LAUNCHING ACTIVITIES

Sequence No.	Date launched	Launch rocket	Payload	Payload mass (kg)	Altitude of perigee (km)	Altitude of apogee (km)	Orbital inclination (deg)	Orbital period (min)	Remarks
1	24/4/70	CZ-1	Dongfanghong-1 satellite	173	439	2 384	68.5	114	
2	3/3/71	CZ-1	Shijian-1 satellite	221	266	1 826	69.9	106	Fallen to earth
3	26/7/75	FB-1	Technical experimental satellite	1 109	185.8	464.1	69.01	90.9	Fallen to earth
4	26/11/75	CZ-2	Re-entry-type remote sensing satellite	1 790	173	483	63	91	Fallen to earth
5	16/12/75	FB-1	Technical experimental satellite	1 108	183.6	387	69	90.2	Fallen to earth
6	30/8/76	FB-1	Technical experimental satellite	1 082	191.2	2144.373	69.2	108.7	Fallen to earth
7	7/12/76	CZ-2	Re-entry-type remote sensing satellite	1 812	167	489	59	91	Fallen to earth
8	26/1/78	CZ-2	Re-entry-type remote sensing satellite	1 810	163	488	57	91	Fallen to earth
9	20/9/81	FB-1 (III)	Shijian-2 (3 satellites)	755	237.2	1 621.3	59.4	103.5	Fallen to earth
10	9/9/82	CZ-2C	Re-entry-type remote sensing satellite	1 783	169	395	63	90	Fallen to earth
11	19/8/83	CZ-2C	Re-entry-type remote sensing satellite	1 842	175	404	63	90	Fallen to earth
12	29/1/84	CZ-3	Experimental satellite	932	400	450	31.1	93	Fallen to earth

/...

TABLE 2 (continued)

Sequence No.	Date launched	Launch rocket	Payload	Payload mass (kg)	Altitude of perigee (km)	Altitude of apogee (km)	Orbital inclination (deg)	Orbital period (min)	Remarks
13	8/4/84	CZ-3	Experimental communications satellite	932	400	35 957	31.1	638	
14	12/9/84	CZ-2C	Re-entry-type remote sensing satellite	1 809	174	408	68	90	Fallen to earth
15	21/10/85	CZ-2C	Re-entry-type remote sensing satellite	1 820	173	402	63	90	Fallen to earth
16	1/2/86	CZ-3	Operational communications and broadcasting satellite	938	400	35 957	31.1	638	
17	6/10/86	CZ-2C	Re-entry-type remote sensing satellite	1 820	175	397	57	90	Fallen to earth
18	5/8/87	CZ-2C	Re-entry-type remote sensing satellite	1 820	175	489	63	91	Fallen to earth
19	9/9/87	CZ-2C	Re-entry-type remote sensing satellite	2 100	205	315	63	90	Fallen to earth
20	7/3/88	CZ-3	Operational communications satellite	1 024	200	35 973	31.1	635	
21	5/8/88	CZ-2C	Re-entry-type remote sensing satellite	2 100	175	400	63	90	Fallen to earth
22	7/9/88	CZ-4(A)	Fengyun-1 meteorological satellite	780	883	918.4	99.2	103	
23	22/12/88	CZ-3	Operational communications satellite	1 024	200	35 973	31.1	635	
24	4/2/90	CZ-3	Operational communications satellite	1 024	200	35 973	31.1	635	

TABLE 3

STATISTICS ON OBJECTS IN ORBIT FROM MAJOR LAUNCHING STATES

	Number of payloads (pieces)	Percentage (%)	Number of fragments (pieces)	Percentage (%)	Total (pieces)	Percentage (%)
ESA	16	0.9	461	8.5	477	6.6
France	15	0.3	25	0.5	40	0.6
Japan	34	1.9	47	0.8	81	1.1
USA	535	30.1	2 622	48.5	3 157	43.9
USSR	1 073	60.4	2 241	41.5	3 314	46.1
Other States	104	5.9	11	0.3	115	1.7
TOTAL	1 777	100	5 407	100	7 184	100

DENMARK

[Original: English]

No research on space debris is taking place in Denmark. However, being a member of the European Space Agency (ESA), Denmark is involved in and supports the activities of ESA in the field of research on space debris.